Atty Docket No. 027006-000100US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Ronald D. BLUM, ET AL. Application No.: 09/994,860 Filed: November 28, 2001 For: METHOD AND APPARATUS FOR REDUCING THE INTENSITY OF HURRICANES AT SEA BY DEEP-WATER UPWELLING Customer No.: 20350	Confirmation No. 9812 Examiner: Boeckmann, Jason Technology Center/Art Unit: 3752

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DECLARATION UNDER 37 C.F.R. § 1.132

I, Isaac Ginis Ph.D., declare the following:

1. I am a tenured Professor of Oceanography at the University of Rhode Island. I hold a doctorate in Geophysics, specializing in Oceanography and Meteorology. A copy of my resume is attached as Exhibit A.

2. I am a leading expert in numerical modeling and forecasting of air-sea interaction during hurricanes. I have published over 70 papers in scientific journals and books on this topic and authored a chapter on hurricane-ocean interaction for the book "Global Perspectives on Tropical Cyclones" published by the World Meteorological Organization, Geneva, Switzerland in 1995. I have delivered over 100 lectures worldwide at national and international meetings as well as at oceanographic and atmospheric institutions and have advised 12 doctoral students and

postdoctoral scientists. The National Science Foundation, the National Oceanic and Atmospheric Administration, the U.S. Office of Naval Research supported my research.

3. I have been leading the effort toward improvements of the GFDL/URI coupled hurricane model related to the ocean and wave coupling. This work involves close collaboration between my research group at URI and scientists at the NOAA's National Centers for Environmental Prediction (NCEP) and Geophysical Fluid Dynamics Laboratory (GFDL). My research group has made a successful conversion of a research coupled hurricane-ocean research model to a fully automated real-time prediction system. This significant technological and computer programming effort has resulted in implementation of the GFDL/URI coupled hurricane model to operational forecasting at National Weather Service in 2001. This model is used by the National Hurricane Center for issuing official hurricane warnings. I continue to be responsible for maintaining and improving the coupled hurricane operational forecast system at NCEP.

4. I have been retained by the assignee of the above-identified application to assist in responding to the Office Action. I have no financial interest in the assignee or the outcome of this patent application, including whether it issues as a patent or not. I am being compensated for the time spent on this matter at the rate of $200/hr, plus reasonable expenses.

5. I have read and am familiar with the above-referenced application. I have also read and am familiar with the Office Action mailed May 4, 2007 ("Office Action") pertaining to this application.

6. It is my understanding that the claims currently under examination, which relate to, *inter alia*, methodologies for reducing the intensity of a hurricane, were rejected as allegedly being wholly inoperative, lacking credible utility, and not enabled. Specifically, the Examiner asserts:

> …applicant admits in his arguments, "submersibles of the kind required for this application do not presently exist." It seems that applicant wishes that someone will come along and develop the technology required to make the required submersibles, thereby enabling the present invention. Therefore, it is impossible for one

> of ordinary skill in the art at his time to make and or use this invention. Office Action at page 6.

7. The disclosure contains sufficient evidence and reasoning that a person of skill in the art would appreciate that since a hurricane draws energy from the heat content of the upper ocean, it is generally accepted that a large area of cooled ocean surface can suppress hurricane intensity. For example, the specification states:

> [0005] Because tropical storms draw their energy from the heat content of the upper ocean, it is generally accepted that a large area of cooled ocean surface can suppress hurricane intensity. Numerical modeling studies at the Massachusetts Institute of Technology suggests that reduction of sea surface temperature by 2.5ºC in the storm's central core would eliminate the thermodynamic conditions that sustain hurricanes. Other numerical model studies by independent researchers corroborate these results. In addition, analyses of measurements from past hurricanes show a strong correlation between lack of hurricane intensification and conditions that favor cold-water upwelling by the storm's own winds, such as a shallow thermocline or slow forward speed. Finally, there is clear evidence that hurricanes weaken (or do not intensify under otherwise favorable conditions) when a hurricane crosses the cold "wake" of a previous storm.

I agree with this assertion in the specification, which is consistent with the knowledge of one skilled in the art at the time of filing the application. Indeed, as detailed below, I conducted numeric modeling that illustrates that reduction of the temperature in the storm's central core would reduce the wind speed of the hurricane, and hence the intensity of the hurricane.

8. Variability in hurricane intensity originates from two sources: internal variability and environmental interactions. An important aspect of environmental interaction is the coupling between the storm and the underlying ocean. It is well known that tropical cyclones are driven by turbulent heat fluxes from the ocean (Ooyama, 1969) and it is natural to suppose that variability in surface conditions and in the response of the upper ocean to the passing storm plays a role in controlling storm intensity.

9. The effect of air-sea interaction as a negative feedback on tropical cyclone development and intensity has been well established. It is known that strong surface winds in a tropical cyclone induce turbulent mixing in the upper ocean and entrainment of the underlying cold water into the ocean mixed layer, which cools and deepens (e.g., Price 1981, Bender et al. 1993, Ginis 2002). Both observational and real case numerical studies (e.g., Black, 1983; Bender and Ginis 2000) showed that the SST anomalies induced by tropical cyclones can reach up to 5-6°C. Studies also showed that tropical cyclone intensity is more sensitive to the local SST changes under the hurricane core than to those beyond the core area (e.g., Emanuel, 1999; Shen et al., 2000). Therefore, it can be expected that cooling of the ocean area underneath the hurricane core may reduce its intensity.

10. Numerical modeling studies suggest that a reduction of sea surface temperatures by 2.5° C in the storm's central core would eliminate the conditions that sustain hurricanes (Emanuel, 1986, 1988). Numerical simulations with coupled models (Khain and Ginis, 1991, Bender et al., 1993) and the operational GFDL/URI coupled hurricane-ocean model forecasts (Bender et al, 2007) indicate that *most* tropical cyclones experience a noticeable reduction of intensity owing to their coupling with the ocean, though the degree of reduction depends on many aspects of the upper ocean thermal structure and the speed of translation, size and initial intensity of the tropical cyclone. This coupling also depends on the surface heat and momentum exchange, which affects mean currents and turbulence in the ocean mixed layer and thereby influences the degree of mixing through the seasonal thermocline.

11. For this declaration, I have conducted a set of numerical experiments to assess the impact on hurricane intensity of a region with the reduced upper ocean heat content (hereafter "cooled" region) placed in front of a moving hurricane. I used the NOAA operational GFDL/URI coupled hurricane-ocean model (Bender et al. 2007) with idealized, but realistic, oceanic and atmospheric conditions. The GFDL hurricane prediction system became operational in 1995 as the U.S. National Weather Service's official hurricane model. Since that time, it has provided forecast guidance to forecasters at the NWS's Tropical Prediction Center (TPC) and has been the most

reliable forecast model for track error during the past decade (Table 1, courtesy of James Franklin, TPC). Table 1 is attached as Exhibit B.

12. Important upgrades to the physics and spatial and vertical resolutions have been introduced to the GFDL/URI model over the years. These upgrades led to significant increase in GFDL/URI model intensity forecast skill (Bender et al, 2007). The operational GFDL/URI model presently has about 9 km spatial resolution in the innermost movable mesh. For this study, I increased the finest resolution to about 4.5 km to improve further its intensity forecast skill.

13. For these idealized experiments, I integrated the coupled model for 120 hours starting with a normal size initial hurricane vortex embedded in specified initial, horizontally uniform environmental conditions. A GATE (Global Atlantic Tropical Experiment) III condition in the tropics is used for the atmospheric environmental thermal profile, which has air temperature of 27^0C and relative humidity of 84% at the lowest model level (about 35 m). A steady easterly environmental wind of 5 m/s was used (the hurricane is moving north-west). In the control experiment, the ocean was initially horizontally uniform and motionless with the sea surface temperature of 28.5^0C. The initial vertical temperature profile with a mixed layer depth of 30 m is typical for the northern Gulf of Mexico in September.

14. Simulation of the SST response in the control experiment is shown in Figure 1, attached as Exhibit C. A typical SST cooling pattern is generated due to hurricane-ocean interaction. The largest cooling is on the right sight of the hurricane track, consistent with observations and other modeling studies (Ginis, 2002).

15. In the first two sensitivity experiments, I introduced the cooled regions in front of the moving hurricane as shown in Figure 2, attached as Exhibit D. The size of each region is about 400 km in the along-track direction and covered the entire computational domain in the cross-track direction. The temperature anomalies in the regions are 1°C and 2°C, correspondingly, which are evenly distributed over the depth of the mixed layer.

16. The main results are summarized in Figures 3 and 4 (Figure 3 is attached as Exhibit E and Figure 4 is attached as Exhibit F). The temperature anomalies (SSTA) underneath the hurricane core, defined as a circular area around the storm center with R=100 km, are shown in Figure 3. The SSTA are greatly reduced when the hurricane crosses the cooled regions. Evolution of hurricane central pressure and maximum winds in the numerical experiments are shown in Figure 4. In both sensitivity experiments the hurricane intensity was reduced after the storm encounters the cooled regions. The maximum winds were reduced from about 145 kts to about 135 kts (6% reduction) in the 1°C swath experiment and to about 130 kts (10% reduction) in the 2°C swath experiment.

17. I conducted an additional experiment in which the size of the 2°C cooled region was doubled along the track direction. As result, the hurricane intensity was further reduced from about 145 kts to about 120 kts (22% reduction). These sensitivity experiments clearly indicate that both the size and magnitude of the cooled area encountered by a moving hurricane make important impact on the hurricane intensity reduction.

18. A list of references cited herein are attached as Exhibit G.

19. All statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further, that the statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and such willful false statements may jeopardize the validity of the application or any patents issuing thereon.

Isaac Ginis ______________________ Date 11.05.07

Isaac Ginis, Ph.D.

Exhibit A

Curriculum Vita

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Professional Preparation:

Kabardino-Balkarian State University, Nalchik, Russia	Mathematics	M.S.	1977
Institute of Experimental Meteorology, Obninsk, Russia	Geophysics	Ph.D.	1986

Appointments:

2003-present	Professor of Oceanography, University of Rhode Island
2006 - Fall	Visiting Research Scholar, Princeton University, Princeton, NJ
1998-2003	Associate Professor of Oceanography, University of Rhode Island
1993-1998	Associate Marine Research Scientist, Adjunct Professor of Oceanography University of Rhode Island
1990-1993	Visiting Research Scientist, Geophysical Fluid Dynamics Laboratory/NOAA Princeton University, Princeton, NJ
1977-1989	Research Scientist, Institute of Mechanics and Applied Mathematics, Kabardino-Balkarian State University, Nalchik, Russia

Awards

National Oceanic and Atmospheric Administration 2001 Outstanding Scientific Paper Award
National Science Foundation Atmospheric Sciences Division 2001 Highlighted Research Project
National Oceanic and Atmospheric Administration 2002 Environmental Hero Award
National Oceanographic Partnership Program 2002 Excellence in Partnering Award

Journal Publications (last 3 years)

Bender, M.A., **I. Ginis**, R. Tuleya, B. Thomas, T. Marchok, 2007: The operational GFDL coupled hurricane-ocean prediction system and a summary of its performance. *Mon. Wea. Rev*. In press.

Moon, I., **I. Ginis**, and T. Hara, B. Thomas, 2007: Physics-based parameterization of air-sea momentum flux at high wind speeds and its impact on hurricane intensity predictions. *Mon. Wea. Rev.* **135**, 2869-2878.

Moon, I., **I. Ginis**, and T. Hara, 2007: Impact of reduced drag coefficient on ocean wave modeling under hurricane conditions, *Mon. Wea. Rev.* In press.

Yablonsky, R. M., I. Ginis, 2007: Improving the initialization of coupled hurricane-ocean models by assimilating mesoscale oceanic features. *Mon. Wea. Rev*. In press.

Fan Y., **I. Ginis**, T. Hara, Il Ju Moon, 2007: Energy and momentum budget across air-sea interface. Part I: Steady Uniform Wind, *J. of Atmos. Sci.* Submitted.

Fan Y., **I. Ginis**, T. Hara, Il Ju Moon, 2007: Energy and momentum budget across air-sea interface. Part II: Hurricane Wind, *J. of Atmos. Sci.* Submitted.

Falkovich, A., and **I. Ginis**, 2005: Ocean data assimilation and initialization procedure for the Coupled GFDL/URI Hurricane Prediction System. *J. Atmos. Oceanic Technol.,* **22,** 1918-1932.

Ginis, I., A.P. Khain, E. Morozovsky, 2004: Effects of large eddies on the structure of the marine boundary layer under strong wind conditions, *J. Atmos. Sci.*, **61**. 3049-3064.

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Moon I.J., **I. Ginis,** T. Hara, E. J. Walsh, and H. L. Tolman, 2003: Numerical modeling of sea surface directional wave spectra under hurricane wind forcing, *J. Phys. Oceanogr*., **33**, 1680–1706.

Frolov, S.A., Sutyrin, G.G., and **I. Ginis**, 2004: Asymmetry of the stabilized Gulf Stream system. *J. Phys Oceanogr*., **34**, 1087-1102.

Knutson, T.R., R.E. Tuleya, **I. Ginis**, 2004: Impact of climate change on hurricane intensity as simulated using regional high-resolution models. Book Chapter. Columbia University Press.

Synergistic Activities

I've been leading the effort toward improvements of the GFDL/URI coupled hurricane model related to the ocean and wave coupling. This work involves close collaboration between my research group at URI and scientists at the NOAA's National Centers for Environmental Prediction (NCEP) and Geophysical Fluid Dynamics Laboratory (GFDL). My research group has made a successful conversion of a research coupled hurricane-ocean research model to a fully automated real-time prediction system. This significant technological and computer programming effort has resulted in implementation of the GFDL/URI coupled hurricane model to operational forecasting at National Weather Service in 2001. This model is used by the National Hurricane Center for issuing official hurricane warnings. We continue to be responsible for maintaining and improving the coupled hurricane operational forecast system at NCEP. A number of major improvements have been made to the operation model for the 2002-06 hurricane seasons which led to significant improvements of the GFDL model forecast skill. Through ongoing collaboration with GFDL, Navy's Fleet Numerical Meteorology Center (FNMOC) and Joint Typhoon Warning Center (JTWC) we are transitioning the new version of the GFDL/URI hurricane model to operations at FNMOC for global tropical cyclone forecasting. Since 2006 my research group has been actively involved in developing the new generation Hurricane Weather, Research and Forecast (HWRF) model in collaboration with EMC/NCEP scientists. We focus our effort on developing and improving the ocean and wave components of the coupled HWRF system. We also collaborate with scientists at the Korean Oceanography and Development Institute in developing a coupled tropical cyclone-ocean model for the western Pacific.

I have developed new courses at URI that cover various numerical methods applied for solving the fundamental equations governing atmospheric and oceanic motions, marine geophysics, and biophysics.

Research Collaborators within Last 48 Months
M. Bender, R. Tuleya, T. Marchok (GFDL/NOAA), A. Khain (HIUJ), G. Sutyrin, L. Rothstein, T. Hara (URI), Il-Ju Moon (JU, Korea), H. Tolman, N. Surgi, C. Lozano (NCEP/NOAA), E. Walsh (NOAA/ETL and NASA/GSFC), K. Emanuel (MIT), Sok Kuh Kang (KORDI).

Graduate Students and Postdoctoral Fellows Advised/Sponsored
Sergey Frolov (PhD), Evan Robertson (MS), Minoru Kadota (MS), Yalin Fan (PhD), Dr. Clark Rowley, Dr. Weixing Shen, Dr. Ray Richardson, Dr. Il-Ju Moon, Richard Yablonsky(PhD - present), Zhitao Yu (PhD- present), Erica Clay (PhD- present), Seunghoun Lee (PhD – present), Lou Licate (MS – present), Dr. Biju Thomas (present), Dr. Yalin Fan (present).

Exhibit B

VERIFYING TIME	***NUMBER OF CASES***	***GFDI***	***GFSI***	***UKMI***	***NGPI***
00	2252	8.	8.	8.	8.
12	2128	**38.8**	42.8	44.9	43.3
24	1952	**67.1**	73.7	77.7	74.2
36	1741	**93.9**	104.4	108.8	105.4
48	1511	**122.8**	135.2	136.7	137.4
72	1159	**192.4**	208.0	195.0	206.1

TABLE 1 *Average track errors in nautical miles [nm] for all forecasts run in the Atlantic between 1996 and 2005 for the GFDL, NCEP's GFS, UKMET and Navy's NOGAPS models. Results are for the time interpolated models. Since numerical weather prediction models are generally not available to the forecasters in time to make their forecasts, a simple technique exists to take the model forecasted position and intensity, and adjust the forecast to apply to the current synoptic time and initial conditions. This adjustment is usually 6 or 12 hours, depending on the availability of the last model guidance. These adjusted versions are known for historical reasons as interpolated models which are generally indicated by the letter "I" at the end of the name (e.g., GFDI for the GFDL interpolated model).*

Exhibit C

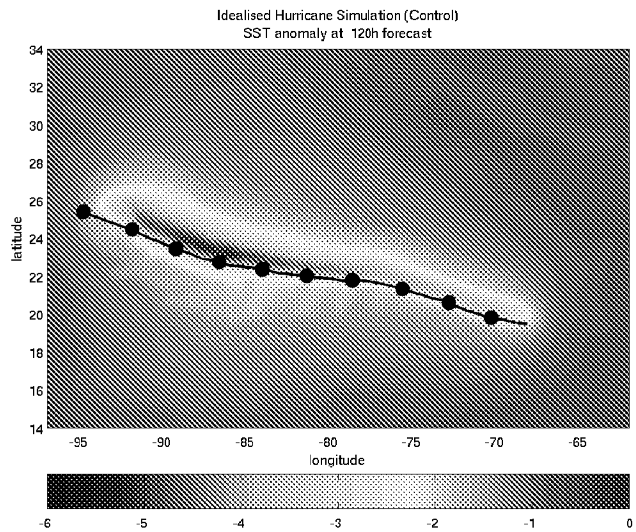

Figure 1. *SST anomalies at 120 h in the control experiment.*

Exhibit D

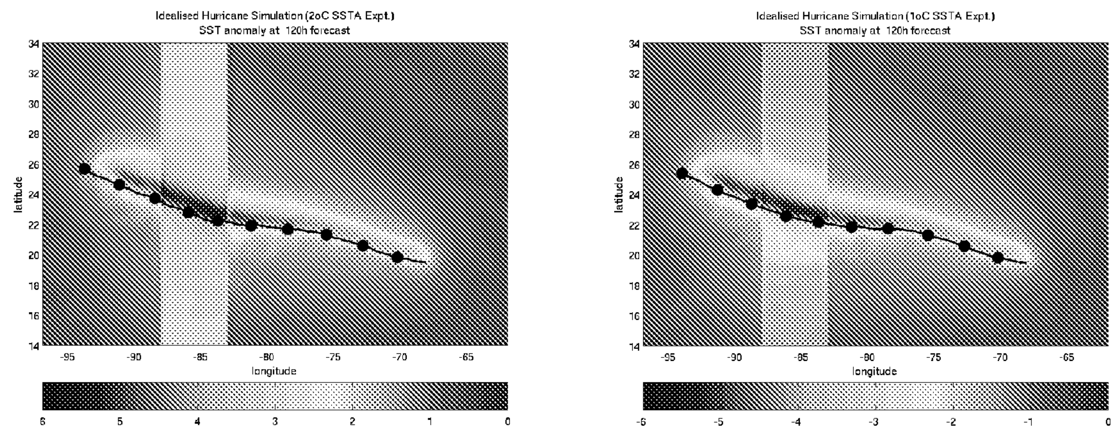

Figure 2. *SST anomalies at 120 h in two sensitivity experiments, where cooled regions of 1^{o}C (left panel) and 2^{o}C (right panel) temperature anomalies are placed in front of the hurricane.*

Exhibit E

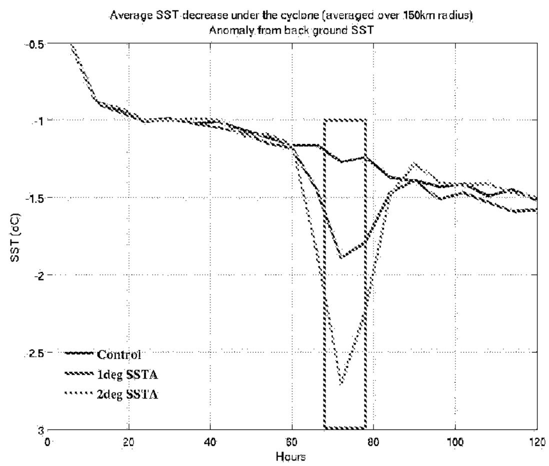

Figure 3. *SST anomalies (SSTA) underneath the hurricane core region, defined as a circular area around the storm center with R=100 km, as function of time. The rectangular box indicates the time when the hurricane center crossed the region with the reduced upper ocean heat content.*

Exhibit F

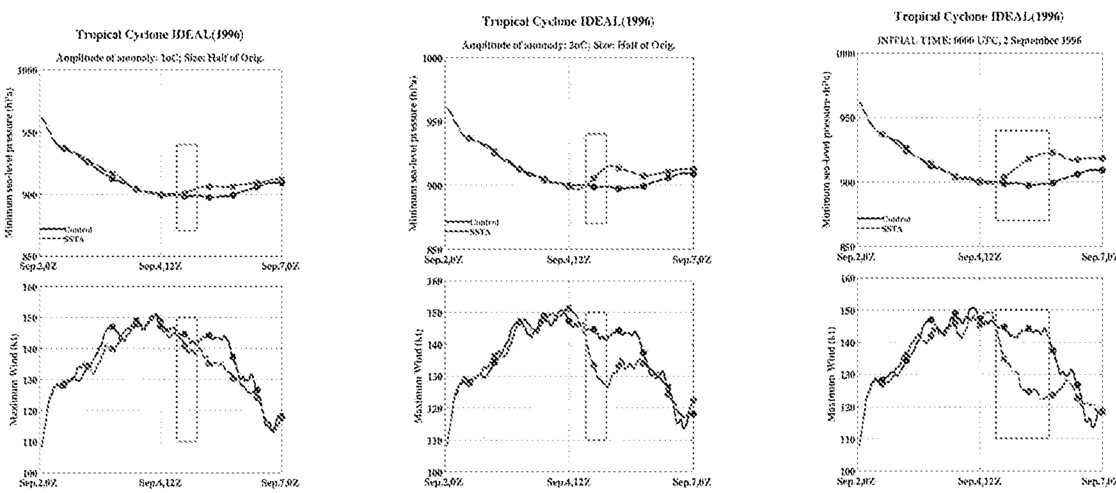

Figure 4. *Evolution of central pressure and maximum winds in four numerical experiments: 1) control (blue line), 2) 1^{o}C anomaly (left panel, red), 3) 2^{o}C anomaly (middlet panel, red,) and 4) the same as 1) and 2) except the size of the cooled swath in the along track direction is twice larger. The green rectangular boxes indicate the time when the hurricane center crossed the regions with the reduced upper ocean heat content.*

Exhibit G

REFERENCES

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Shen, W., R. E. Tuleya, and I. Ginis, 2000: A Sensitivity study of the thermodynamic environment on GFDL hurricane intensity: Implications for global warming, J. of Climate, 13, 109-121.